WATER SERVICES ASSOCIATION OF AUSTRALIA

WSA 201:2020 Manual for Selection and Application of Protective Coatings Second Edition Version 2.2

Amendment No 1

BACKGROUND

The proposed changes are the result of field trials and research related to calcium aluminate cement mortars and geopolymer mortars under the Smart Linings for Pipe and Infrastructure Project. Additional information can be found about this project here: https://waterportal.com.au/smartlinings/

The 2020 edition of WSA 201 is amended as follows:

SUMMARY This amendment applies to the following elements:

Referenced Documents, Definitions, Abbreviations, Coating inspector, Design service life of assets, Exposure class details, Coating systems and general description, Recommended coating systems for sewage pipelines and associated items, Recommended coating systems for treatment plants and pumping stations, Recommended coating systems for specific maintenance painting, Surface Preparation – Cementitious Substrate, Existing Coatings, Preparation of concrete substrate for cementitious coating application (new), Coating Application, Repair of defects in new coatings, Cement based coating application (new), CAC (calcium aluminate cement), GEO (geopolymer cement mortar), Product specifications, Surface cleanliness, Moisture content – concrete and masonry structures, Dry film thickness – concrete substrates, Defects for cementitious coatings (CAC & GEO) (new), Acceptance testing for cementitious coatings (CAC & GEO) (new), Clauses 1.6, 1.7, 1.8, 2.5, 5.2, Table 5.1, Table 5.2, Table 5.3, Table 5.5, Table 5.6, Table 5.8, 6.5.2.1, 6.2.5.4, 6.2.5.6, 6.2.6.1, 6.2.6.2, 6.3.10 (new), 7.1, 7.14, 7.19 (new), 8.3, 8.18 (new), Table 9.1, 10.3.4, 10.3.8, 10.3.11, 10.3.16 (new), 10.4 (new), Table 13.4

Published on: To be advised

Approved for publication on behalf of the Water Services Association of Australia on TBA.

<table>
<tr><th>Section / Reference</th><th>Proposed Change</th></tr>
<tr><td>1.6 Referenced Documents</td><td>Addition of the following:
<table>
<tr><td>AS 1012.9</td><td>Determination of the compressive strength of concrete specimens</td></tr>
<tr><td>AS 1379</td><td>Specification and supply of concrete</td></tr>
<tr><td>AS 1580.408.5</td><td>Paints and related materials - Methods of test - Adhesion - Pull-off test</td></tr>
</table></td></tr>
</table>

<table>
<tr><th>Section / Reference</th><th>Proposed Change</th></tr>
<tr><td></td><td>
<table>
<tr><td>ASTM C150/C150M</td><td>Standard Specification for Portland Cement</td></tr>
<tr><td>ASTM F1869</td><td>Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride</td></tr>
<tr><td>BS EN 14647</td><td>Calcium aluminate cement – Composition, specification and conformity criteria</td></tr>
<tr><td>EN 196-1</td><td>Methods of testing cement - Part 1: Determination of strength</td></tr>
<tr><td>EN 196 – 2</td><td>Method of testing cement – Part 2 Chemical analysis of cement</td></tr>
</table>
</td></tr>
<tr><td>1.7 Definitions</td><td>Addition of the following:
<table>
<tr><td>Admixtures</td><td>Those ingredients in concrete, or mortar, other than cement, water, and aggregates that are added to the mixture immediately before or during mixing. Admixtures are chemical formulations added to the concrete, or mortar, mix that affect the way the plastic or hardened mortar performs.</td></tr>
<tr><td>Acid Neutralisation Capacity</td><td>Measures the buffering capacity of concrete against acidification</td></tr>
<tr><td>Alkaline component</td><td>Combinations of alkali and alkali earth containing salts, minerals and glasses.</td></tr>
<tr><td>Cement</td><td>Hydraulic powder that reacts with water to form a hardened solid mass.</td></tr>
<tr><td>Calcium Aluminate Cement</td><td>Calcium aluminate cement is a hydraulic binder with a high alumina content. It is a finely ground inorganic material which when mixed with water forms a paste that sets and hardens by means of hydration reactions and processes. The main component of calcium aluminate cement is mono-calcium aluminate ($CaO.Al_2O_3$).</td></tr>
<tr><td>Calcium Aluminate Cement Mortar (CAC)</td><td>A mortar that uses calcium aluminate cement as the hydraulic binder. The CAC may contain aggregate calcium aluminate cement clinker or siliceous aggregates. Aggregates shall be fine (≤ 5 mm).

The CAC may also contain supplementary cementitious materials, e.g. pozzolans, flyash, slag, and chemical admixtures to achieve required mortar properties.</td></tr>
<tr><td>Coating</td><td>A layer of any substance spread over any surface.</td></tr>
</table>
</td></tr>
</table>

Section / Reference	Proposed Change	
	Calcium aluminate cement Conversion	The transformation of meta-stable to stable calcium aluminate cement hydrates accompanied by rise in the porosity and reduction in strength of the CAC.
	Corrosion Classification	A classification system that provides a grade to an asset from 1 to 5 based on the environment in the sewer and its impact on the expected life of the asset.
	Cured geopolymer	Geopolymer product that has completed a polycondensation reaction process. Curing can be carried out at ambient conditions (20-23°C) for on-site application for periods of 28 to 56 days. Curing can be accelerated with heat or steam at 40-140°C for periods from 8 to 24 hours followed by rest periods of 7 to 28 days.
	Geopolymer	A geopolymer is an inorganic cement binder. Geopolymers are prepared by reacting aluminate and silicate bearing minerals, and/or waste, with an alkaline activator resulting in a polycondensate structure.
	Geopolymer cement mortar (GEO)	A mortar that uses geopolymer as the hydraulic binder. The GEO contains aggregates that maybe natural or wastes, e.g. glass. Aggregates shall be fine (≤ 5 mm). The GEO may also contain supplementary cementitious materials, e.g. pozzolans, flyash, slag, and silica fumes, and chemical admixtures to achieve required mortar properties.
	Liner	a protective layer of material formed over the substrate after installation and curing is completed.
	Two-part geopolymer	Aluminosilicate activated with alkaline reagent solution, e.g. sodium (or potassium) silicate and sodium (potassium) hydroxide). Two-part geopolymers are used for pre-cast concrete.
	One-part geopolymer	Aluminosilicate activated with blends of solid alkaline reagent. This avoids handling highly caustic solution. The preparation involves mixing the one-part geopolymer with water. One-part geopolymers are used for on-site construction
	efflorescence	Migration of salts to the surface of concrete. Some salt formation can be accompanied by cracking.
1.8 Abbreviations	Addition of the following: CAC - Calcium aluminate cement mortar	

<table>
<tr><th>Section / Reference</th><th>Proposed Change</th></tr>
<tr><td></td><td>GEO - Geopolymer cement mortar</td></tr>
<tr><td>2.5 Coating inspector</td><td>Add the following paragraph to Clause 2.5:

For coatings over concrete in extreme exposure class conditions (Refer to Table 5.1), the Inspector shall hold SSPC CCI Level 2 certification. For all other coatings applied to concrete, the Inspector will hold SSPC CCI Level 1 certification.</td></tr>
<tr><td>5.2 Design service life of assets</td><td>Addition of the following as the last paragraph:

The durability of the protective coating systems (the time elapsed before first major maintenance) is typically 15 to 25 years depending on the exposure environment, thus monitoring protocol, condition assessment that needs to be compared to failure prediction model(s) will guide maintenance/replacement program over the Design Service Life of all structures.</td></tr>
<tr><td>5.3 Exposure class</td><td>Addition of the following as the third paragraph:

Concrete wastewater assets (both reinforced and unreinforced) contain variable environments inside and outside the asset that influence the rate of internal corrosion. These environments are classified from 1 (low corrosivity) to 5 (extreme corrosivity). A model to determine the corrosion classification using field measurement of H_2S, CO_2, relative humidity, temperature, infiltration and soil corrosivity is available at [location TBC, fact sheet with details available here]. Corrosion classifications that approximately correspond the exposure class details are included in Table 5.1, however use of the model is recommended.</td></tr>
<tr><td>Table 5.1 Exposure class details</td><td>Addition of column containing details of corrosion classification for concrete wastewater assets (internal environment). Highlighted elements are new, non-highlighted elements kept for reference (no changes proposed for steel and reinforced concrete columns):
<table>
<tr><th>Exposure Class</th><th>Corrosion Classification for concrete wastewater assets (internal environment)</th></tr>
<tr><td>Extreme</td><td>Corrosion Classification 5
H_2S > 155 ppm
CO_2 <2500
Temperature 15-28°C
Relative Humidity 95-99%</td></tr>
<tr><td>Immersion & buried</td><td>NA</td></tr>
<tr><td>High</td><td>Corrosion Classification 4
H_2S: 135-155 ppm
CO_2: 2500-4000</td></tr>
</table></td></tr>
</table>

<table>
<tr><th>Section / Reference</th><th>Proposed Change</th></tr>
<tr><td></td><td>
<table>
<tr><td></td><td>• Temperature 15-28°C
• Relative Humidity 95-99%</td></tr>
<tr><td>Moderate</td><td>Corrosion Classification 3
• H_2S: 70-135 ppm
• CO_2: 4000-9300
• Temperature 15-28°C
• Relative Humidity 95-99%</td></tr>
<tr><td>Low</td><td>Corrosion Classification 2
• H_2S: 15-70 ppm
• CO_2: 9300-9400
• Temperature 15-28°C
• Relative Humidity 95-99%</td></tr>
<tr><td>Very Low</td><td>Corrosion Classification 1
• H_2S: <15 ppm
• CO_2: 9400 - 9500
• Temperature 15-28°C
• Relative Humidity 95-99%</td></tr>
<tr><td colspan="2">Notes
Corrosion classification measurements are to be used in conjunction with a model to determine the required application thickness for the desired service life under these conditions. The model is available at [location TBC, fact sheet with details available here].</td></tr>
</table>
</td></tr>
<tr><td>Table 5.2
Coating systems and general description</td><td>CAC system description.
Replace:
Calcium aluminate cement mortar is a lining material specially designed for refurbishment concrete structures in sewer environment and for lining of cast iron and steel pipes and fittings used for conveying sewage. Its durability highly depends on the sewer environment. Refer to WSAA Information and Guidance Note TN6. Not suitable for chemical bund/sump pit lining.
With:
Calcium aluminate cement mortar is a lining material specially designed for protection and refurbishment of concrete structures, pipes, and fittings used for conveying sewage. Its durability is highly dependent on the sewer environment. Not suitable for chemical bund/sump pit lining.</td></tr>
<tr><td>Table 5.2
Coating systems and general description</td><td>Addition of geopolymer description to table
System: GEO
Description:
Geopolymer cement mortar is a lining material specially designed for protection</td></tr>
</table>

<table>
<tr><th>Section / Reference</th><th>Proposed Change</th></tr>
<tr><td></td><td>and refurbishment of concrete structures, pipes, and fittings used for conveying sewage. Its durability is highly dependent on the sewer environment.
Suitable substrates:
• Steel: No
• Concrete: Yes
Intended service condition: Atmospheric and immersion</td></tr>
<tr><td>Table 5.3

Recommended Coating Systems for Water Reservoirs</td><td>Add superscript 6 to second column

<table><tr><td>Reservoir roof framing, roof supporting structures, roof cladding underside</td><td>Steel, galvanized steel[2,6]</td><td>Immersion</td><td>EHB-SF, EHB-SB, GAL</td></tr></table>
Add additional Note 6 under table 5.3
(6) Immersion zone includes water vapour space. Refer to Table 5.1 for further exposure class details.</td></tr>
<tr><td>Table 5.5
Recommended coating systems for sewage pipelines and associated items</td><td>Addition of “GEO” to table under heading:
• Internal – Pipes, tunnels, maintenance structured – Concrete - Extreme – System.</td></tr>
<tr><td>Table 5.5
Recommended coating systems for sewage pipelines and associated items</td><td>Addition of note 7 as follows:
(7) Refer to [tool location TBC, fact sheet with details available here] to select appropriate CAC and Geopolymer coatings for the appropriate conditions and design life.
Note (7) to apply to CAC and GEO listed in table 5.5 under heading: Internal – Pipes, tunnels, maintenance structured – Concrete - Extreme – System.</td></tr>
<tr><td>Table 5.6</td><td>Addition of “GEO” to table under headings:</td></tr>
</table>

Section / Reference	Proposed Change
Recommended coating systems for treatment plants and pumping stations	• [Internal surfaces of:] Wet-wells, inlet & discharge MH, emergency storage tanks – Old Concrete – Extreme – System; and • [Internal surfaces of:] Tanks, vessels containing agitated sewage, e.g. grit chambers, inlet works, digesters – Old Concrete – Extreme – System.
Table 5.6 Recommended coating systems for treatment plants and pumping stations	Addition of note 9 as follows: (9) Refer to [tool location TBC, fact sheet with details available here] to select appropriate CAC and Geopolymer coatings for the appropriate conditions and design life. Note (9) to apply to CAC and GEO listed in table 5.6 under headings: • [Internal surfaces of:] Wet-wells, inlet & discharge MH, emergency storage tanks – Old Concrete – Extreme – System; and • [Internal surfaces of:] Tanks, vessels containing agitated sewage, e.g. grit chambers, inlet works, digesters – Old Concrete – Extreme – System.
Table 5.8 Recommended coating systems for specific maintenance painting	Addition of “GEO” to table under heading: • Rehabilitation of concrete sewerage structures – Coating System
Table 5.8 Recommended coating systems for specific maintenance painting	New paragraph to section: Rehabilitation of concrete sewerage structures – Coating System – Additional Notes Refer to Sewer Rehabilitation & Prioritisation Decision Platform [tool location TBC, fact sheet with details available here] to select appropriate CAC and Geopolymer coatings for the appropriate conditions and design life.
6.2.5.1 General	Addition of the highlighted sentence to the end of the first paragraph as follows: The following surface preparation requirements normally only applies to concrete and masonry surfaces that will be coated with thermosetting polymer material e.g. epoxy, polyurethane, polyurea, and acrylic. For surface preparation requirements for CAC and Geopolymer coatings refer to section 8.3 (CAC) and 8.18 (GEO).
6.2.5.4	Insert the following paragraph before the last paragraph:

Section / Reference	**Proposed Change**
Contaminated concrete	When preparing the concrete surface for a cement based coating (including CAC and Geopolymers) laitance material shall be removed to achieve surface pH > 8.2, or colour of purple when sprayed with phenolphthalein indicator, followed by application of appropriate surface repair material. A surface pH>8.2 has been shown through laboratory testing to be a critical factor in developing bond strength between the substrate and cementitious coating materials.
6.2.5.6 Concrete repairs	Amend the first paragraph as follows (highlight marks changes): Any corroded concrete, oil, grease, chemical contaminants and existing coatings shall be removed using mechanical means or high pressure water cleaning ~~i.e. greater than 34.47 MPa (5,000 psi)~~ (pressure must be sufficient to remove required material). Any drummy or delaminated concrete sections shall be broken out and removed so that only sound substrate remains.
6.2.5.6 Concrete repairs	Amend the first paragraph as follows (highlight is new): Any infiltration at the crack shall be stopped first prior to undertaking crack repair, using hydrophilic or hydrophobic polyurethanes, in accordance with the methodology approved by the Water Agency.
6.2.6.1 Assessment of existing coatings	Addition of the following sentence at the end of the section: When assessing cementitious coatings, e.g. CACs or geopolymers, an additional test may be performed to assess the depth of acid permeation of the coating.
6.2.6.2 Surface preparation of existing coating	Amend the first paragraph as follows (highlight is new): Where an existing coating is intended to be principally left intact by being spot repaired and overcoated or fully overcoated, the surface preparation requirements specified for the relevant product in section 8 shall apply. Where none are specified, the surfaces shall be washed clean using high-pressure water wash with a minimum 20 MPa with drinking water to remove all salts and mechanically roughened to ensure promotion of good adhesion of the new coating onto the existing one. Remove corrosion by pre-blasting any deteriorated existing coatings and corrosion products.
6.3.10 Preparation of concrete substrate for cementitious coating application	Addition of the following new section: Water jetting, as per 6.3.7, is recommended for removal of damaged concrete material as it reduces micro-cracking in the substrate. Damaged substrate material, or previous coating, shall be removed to specified surface pH > 8.2 , or colour of purple when sprayed with phenolphthalein indicator. A surface pH>8.2 has been shown through laboratory testing to be a critical factor in developing bond strength between the substrate and cementitious coating materials.

Section / Reference	Proposed Change
	Following removal of damaged material application of appropriate surface repair material is required. A corrosion resistant cementitious coating, e.g. CAC or GEO, can be used for repairs if its material properties are adequate. Alternatively, it may be more cost effective to apply a cement mortar to repair the host structure prior to the application of the corrosion resistant coating material.
7.1 General	Replace 'paint' with 'coating' in final paragraph. The Applicator shall record all details of surface preparation, ~~paint~~ coating application, ambient weather conditions and film thickness measurements on daily inspection reports. As a guide, suitable forms are available in AS 3894.10 to 14 inclusive.
7.14 Repair of defects in new coatings	Insert additional requirement as per below (highlight is new): Areas where defects have been detected shall be repaired as follows: (a) Remove all loose and flaking coatings until a sound, tightly adhering edge is achieved. (b) Pre-clean the surface to ensure it is clean and free of oil, grease, dirt and other contaminants. (c) Grind out or sand defective areas sufficiently to ensure the repair coating will penetrate and eliminate the defect. (d) Feather, taper or smooth off all sharp edges of the remaining sound coating to an appropriate degree. (e) Suitably roughen the adjacent sound coating surface to a minimum 20 mm width from the perimeter of the repair spot. (f) Remove all dust. (g) Ensure surface preparation requirements are met for the coating system. (h) Reinstate the surface by re-applying the coating system over the affected area. (i) Where coating touch-up is required, the entire face of the item is to be coated back to an edge or weld or other delineation so that the repaired area is not noticeable. Attempted "blending" of a touch-up repair on a visible face is not acceptable. The aesthetics of all touch-up repairs shall be agreed with the Water Agency.
7.19 Cement based coating application	Addition of the following new section:

7.19CEMENT BASED COATING APPLICATION

7.19.1 General

Cement based coatings can be applied by hand, using a trowel, or by spray, using either a dry-spray or a wet-spray machine. Coatings that are sprayed may require a trowel finish to smooth the surface of the coating.

Dry-spray – where the coating product and water are carried in separate hoses to the nozzle, then mixed at the nozzle immediately prior to spraying. Typically used where coating surface is not adjacent to where the coating components are stored, e.g. a sewer pipe.

Wet-spray – where the coating product and water are mixed above ground and pumped in a single hose to the nozzle. Typically used where the pumping distance is short, e.g. a sewer maintenance hole.

Priming: Some coatings require the concrete surface to be pre-wetted or to have a certain moisture content prior to application. The applicator shall pre-wet and assess the moisture content on the concrete surface as per the manufacturer's instructions prior to application and document this in its quality assurance documentation.

Use by date: Cement based coatings will hydrate with time even when kept in sealed bags. The speed by which the coatings hydrate during storage will dictate their shelf life. The use by date of the coatings shall be checked prior to application. General clumping of the coatings may also suggest that hydration has begun to proceed. Alternatively the moisture content should be <5%.

Water: water used in mixing shall conform to AS 1379.

Unopen bags of cement-based coatings shall be used; to prevent uncontrolled moisture content change.

After application the surface of the coating can be smoothed using a trowel and wet sponge.

7.19.2 Trowel Application Requirements

A spray-applied product on the walls and soffit does not need a trowel finish, providing that the heights between peaks and valleys are less than 1 mm. To achieve a smooth finish of the spray-applied, the shotcrete can be hand-trowelled using either a square or pointed trowel.

7.19.3 Dry Spray Application Requirements

Application is typically achieved continuously, i.e. because the water is applied at the nozzle there are no interruptions when loading a new batch.

Setting Time: Dry spray application is recommended if the setting time of the cement based coating is short. Short set times are preferable for application in the repair of live sewers that are partly full. It is generally expected that coatings will set within 3-4 hours. Suitable admixture may be used to control the plastic behaviour of the cement based coating, but this shall be undertaken in consultation with the manufacturer.

Equipment and mixing: Appropriate dry shotcreting equipment can be used, e.g. single chamber, double chamber or rotary machines. When spraying

Section / Reference	Proposed Change
	concrete with fibres, the fibre size should never be greater than 70% of the nozzle diameter. **7.19.4 Wet Spray Application Requirements** Application is done in batches to allow control of application, in particular material curing. Setting time: For wet spray application the setting time is critical in ensuring the coating sets before the sewer flow reaches its normal operational level, whilst preventing the coating from setting inside the pump. Ideally the area to be sprayed should be easily accessible, e.g. an access chamber. Suitable admixture may be used to control the plastic behaviour of the concrete, but this shall be undertaken in consultation with the manufacturer. Equipment and mixing: A screw feed hopper is used to mix the concrete using a screw pump. The hose must be pressure rated at twice the pump pressure and ID typically > 20 mm with nozzle aperture > 10 mm. Compressed air may be introduced within the annular or centre of the hose. When spraying concrete with fibres, the fibre size should never be greater than 70% of the nozzle diameter.
8.3 CAC (calcium aluminate cement)	Update title to include 'mortar' CAC (calcium aluminate cement mortar)
8.3 CAC (calcium aluminate cement)	Replace text under heading Surface Preparation – Description with: Abrasive blast cleaning, grinding, scarifying, scrabbling or high and ultra-high pressure water jetting to remove laitance, cement-rich fines, and to create the required surface profile/roughness (ICRI Guideline No 310.2, surface profile range CSP 6 to CSP 9). Water jetting, as per 6.3.7, is recommended for removal of damaged concrete material as it reduces micro-cracking in the substrate. Where performing isolated repair: • Saw cut or cut back the extremities of the repair locations to a depth of at least 20 mm to provide a square edge. • Do not feather edges. For both repairs and full substrate coating: • Damaged substrate material, or previous coating, shall be removed to specified surface pH > 8.2, or colour of purple when sprayed with phenolphthalein indicator. • Where the prepared surface has been exposed to air for a few hours or longer, the surface should be scored prior to spraying the phenolphthalein indicator. Non-conforming areas shall be further cleaned and broken out. • Any exposed steel reinforcement shall be cleaned to Class 2½ in accordance with the Appendix B of AS1627.4. Upon cleaning

Section / Reference	Proposed Change
	reinforcements shall be coated with a corrosion resistant, zinc rich, coating within 4 hours of cleaning to avoid flash rusting. • Following removal of damaged material application of appropriate surface repair material may be required, prior to the application of the coating material. No CAC coating shall be applied over the repair material until it has dried or cured in accordance with the manufacturer's instructions.
8.3 CAC (calcium aluminate cement)	Update text under heading Spray Coat – Description as follows (highlight is new): Calcium aluminate cement mortar with calcium aluminate clinker [C12] or siliceous aggregates.
8.3 CAC (calcium aluminate cement)	Amendment to notes as follows (highlight is new): (1) Refer to water industry standard WSA 160. (2) ~~Water: cement ratio shall be between 0.35 to 0.40.~~ Water:concrete ratio and bulk density shall be declared by manufacturer, including allowable tolerance. (3) Glass fibres may be used for strength and shrinkage control. (4) The maximum aggregates size is ~~4~~ 5 mm. (5) Water used in mixing shall be drinking water quality. (6) Accelerators may be used for curing sections that are exposed to early flows, subject to prior approval from the Water Agency. (7) For steel pipes and fittings refer to AS 1579. For ductile iron pipes and fittings refer to AS/NZS 2280. (8) The required application thickness shall be determined using using the Sewer Rehabilitation & Prioritisation Decision Platform for the required service life. It can be accessed [location TBC, fact sheet with details available here]. ~~The minimum thickness of the CAC coating application for a service life of 50 years, over and above any surface~~ ~~restoration or filling surface irregularities, shall be calculated using the following formula.~~ ~~T = 0.3835 [H2S] + 32~~ ~~where;~~ ~~T = CAC coating thickness (mm) [rounded to the nearest 5mm]~~ ~~[H2S] = average concentration of gaseous H2S in the sewer atmosphere (ppm)~~ ~~Sydney Water shall advise the methodology to determine the average~~ (9) Portland based cement (calcium hydroxide) shall not be mixed with the CAC for rapid setting or for any other purposes.

<table>
<tr><th>Section / Reference</th><th>Proposed Change</th></tr>
<tr><td></td><td>(10) No admixture will be allowed unless recommended by the Supplier.

(11) Should admixtures be proposed, the Applicator shall provide reason for its use and the manufacturer’s approval. Preliminary tests will be necessary to demonstrate that the intended results are achieved with a specific admixture.

(12) Coatings are considered to have failed once acids and other corrodents have fully permeated the coating. This is signified by pH of <7.0 of the coating section in contact with the host structure.</td></tr>
<tr><td>8.18 GEO (geopolymer cement mortar)</td><td>Addition of the following new section:
<table>
<tr><th>Item</th><th>Description</th></tr>
<tr><td>Preliminary Cleaning</td><td>Aged concrete: Remove mud, dirt, algae, degenerated coatings or degraded concrete and other contamination.
Wash using pressure water cleaning.</td></tr>
<tr><td>Oil and Grease Removal</td><td>Remove oil and grease in accordance with ASTM D 4258 Standard Practice for Surface Cleaning Concrete for Coating.</td></tr>
<tr><td>Substrate</td><td>Aged concrete. Predominately suitable for aged concrete where surface profile is rough.</td></tr>
<tr><td>Surface Preparation</td><td>Abrasive blast cleaning, grinding, scarifying, scrabbling or high and ultra-high pressure water jetting to remove laitance, cement-rich fines, and to create the required surface profile/roughness (ICRI Guideline No 310.2, surface profile range CSP 6 to CSP 9).
Where performing isolated repair:
Saw cut or cut back the extremities of the repair locations to a depth of at least 20 mm to provide a square edge.
Do not feather edges.
For both repairs and full substrate coating:
Damaged substrate material, or previous coating, shall be removed to specified surface pH > 8.2, or colour of purple when sprayed with phenolphthalein indicator.
Where the prepared surface has been exposed to air for a few hours or longer, the surface should be scored prior to spraying the phenolphthalein indicator. Non-conforming areas shall be further cleaned and broken out.
Any exposed steel reinforcement shall be cleaned to Class 2½ in accordance with the Appendix B of</td></tr>
</table></td></tr>
</table>

<table>
<tr><th>Section / Reference</th><th colspan="2">Proposed Change</th></tr>
<tr><td></td><td></td><td>AS1627.4. Upon cleaning reinforcements shall be coated with a corrosion resistant, zinc rich, coating within 4 hours of cleaning to avoid flash rusting.
• Following removal of damaged material application of appropriate surface repair material may be required, prior to the application of the coating material. No CAC coating shall be applied over the repair material until it has dried or cured in accordance with the manufacturer’s instructions.</td></tr>
<tr><td></td><td>Primer</td><td>Not generally required, consult manufacturer.

Pre-wet and assess the moisture content on the concrete surface as per the manufacturer’s instructions prior to application and document this in the quality assurance documentation.</td></tr>
<tr><td></td><td>Spray Coat</td><td>Geopolymer cement mortar with geopolymer and/or siliceous aggregates [C14].
Nominal DFT 25 mm
Minimum DFT 15 mm
Maximum DFT 75 mm</td></tr>
<tr><td></td><td>Total Dry Film Thickness</td><td>per coat
Nominal DFT 25 mm
Minimum DFT 15 mm
Maximum DFT 75 mm</td></tr>
<tr><td></td><td colspan="2">NOTES:
1. Refer to water Industry standard WSA 161.
2. Geopolymer cement mortar shall consist of geopolymer binder, aggregates, water and admixtures (if any).
3. Water used in mixing shall conform to AS 1379. The temperature of water shall be between 15 and 25°C.
4. No admixture will be allowed unless recommended by the Supplier and approved by the Water Agency.
5. Coatings are considered to have failed once acids and other corrodents have fully permeated the coating. This is signified by pH of <7.0 of the coating section in contact with the host structure.
6. The University of Sydney has developed a free tool that is recommended for use in selecting appropriate locations to use CAC and Geopolymer products and provides an expected service life for a</td></tr>
</table>

<table>
<tr><th>Section / Reference</th><th>Proposed Change</th></tr>
<tr><td></td><td>given thickness based on the corrosion classification. It can be accessed [insert tool location].</td></tr>
<tr><td>Table 9.1 Product specifications</td><td>Update to Table 9.1 as follows (highlight is new, only rows with updates shown):
<table>
<tr><td>C12</td><td>Calcium aluminate cement mortar</td><td>Sydney Water SS
EN 14647
WSA 160</td></tr>
<tr><td>C14</td><td>Geopolymer cement mortar</td><td>Sydney Water SS

WSA 161</td></tr>
</table></td></tr>
<tr><td>10.3.4 Surface cleanliness</td><td>Updates to second paragraph as follows:

For concrete surfaces, ~~only (b) applies~~ it is critical to remove damaged substrate material. In addition to (b), from the above list, the surface shall be shown to be at or above a pH of 8.2. It is recommended to use a spray-on indicator, such as phenolphthalein, which changes from clear to purple when sprayed on a surface > pH 8. 2. A surface pH>8.2 has been shown through laboratory testing to be a critical factor in developing bond strength between the substrate and cementitious coating materials. Following surface cleaning the cementitious coating should be applied within 1-2 weeks to prevent corrosion of the substrate material and ensure sufficient adhesion is formed. If an environment is known to be highly carbonated (H2S>20 ppm and CO2>2500ppm), the coating should be applied as soon as practical after surface preparation is completed.</td></tr>
<tr><td>10.3.4 Surface cleanliness</td><td>Addition of sentence below to end of final paragraph:

For concrete surfaces, where a spray-on indicator, such as phenolphthalein, is used the whole surface should be sprayed in order to identify that surface preparation is completed.</td></tr>
<tr><td>10.3.8 Moisture content – concrete and masonry structures</td><td>Replacement of the third paragraph.

Replace:

Unless otherwise specified and except in case of CAC coating system, coatings shall not be applied if any moisture is found on the backside of the film.

With:

Unless otherwise specified coatings shall not be applied if any moisture is found on the backside of the film. Exception: where using cement-based coating systems, and where no infiltration is present, moisture can be advantageous – follow manufacturer directions.</td></tr>
<tr><td>10.3.11 Dry film thickness –</td><td>Replace the first paragraph:

Replace:</td></tr>
</table>

Section / Reference	Proposed Change
concrete substrates	Regularly measure the DFT of the coating using an ultrasonic thickness tester specifically designed for the measurement of coating thickness on coated concrete substrates in accordance with ASTM D 6132. With: Regularly measure the DFT of the coating: • Using an ultrasonic thickness tester specifically designed for the measurement of coating thickness on coated concrete substrates in accordance with ASTM D 6132; or • For cementitious coatings: Before coating sets: o a ruler can be inserted into the coating to make contact with the substrate, or After coating sets: o Measure using a non-destructive thickness sensor, (where coating is applied ≥20mm thick), or o Take a core sample of the coating and host structure to verify thickness between 48 hours and 1 week of installation. o Where reinforcing bars are present, a cover meter can be used to take measurements before and after coating works, o Laser profiling can be used to take measurements before and after coating works. Sensors used shall be calibrated to the coating material and substrate as applicable and the level of accuracy, e.g. ±X%, shall be displayed in the quality control documentation with the measured thickness. Sensors require approval from the Water Agency for use.
10.3.16 Defects for cementitious coatings (CAC & GEO)	Addition of the following new section: The finished coating shall be free of all defects, which affect the hydraulic performance, structural adequacy or ongoing requirements for operation and maintenance of the sewer. This shall include defects arising from substandard materials, inadequate surface preparation, poor placement, workmanship, or inadequate curing of the mortar. Any defective work will be unacceptable. The only exception is inherent defect(s), as defined by the Applicator and agreed by the Water Agency. Inherent defects shall be those nominated by the Applicator in the Schedule of Technical Data and accepted by the Water Agency. The acceptance limit for each defect shall be those agreed / negotiated with the Water Agency.

<table>
<tr><th>Section / Reference</th><th>Proposed Change</th></tr>
<tr><td></td><td>
During the execution of the contract it may become apparent that there are further inherent defects that have not been nominated earlier by the Applicator. Provided the Applicator can substantiate that such defect(s) constitute an "inherent defect", it may be put to the Water Agency for review.

If accepted, the Water Agency will nominate the acceptance limit for the defect(s) in terms of its frequency and dimension and that shall be binding on the Applicator.

Defects, which are considered unacceptable in all coatings, include, but are not limited to the following:
• Inadequate compressive and bond strength.
• Cracks, fractures.
• Leakage through the coating.
• Uneven surface, poor joints and coating terminations, poor general finish.
• Inadequate cover to reinforcement.
• Excessive mortar loss during application.
• Surface bulges.
• Delamination.
• Excessive distortion, surface roughness.
• Sagging.
• Efflorescence.
• Alkali silica reaction
• Scaling, spalling, blistering.
• Dusting or chalking.
• Surface softening.
• Low self-compaction defects:
  ○ Honeycombing (voids formed when mortar do not fill in the spaces between aggregates).
  ○ Segregation of mortar and aggregates.
  ○ Surface holes (bug holes).
• Any other defect not nominated and agreed as inherent to the coating system.
</td></tr>
<tr><td>10.4 Acceptance testing for cementitious coatings</td><td>
Addition of the following new section:

The various tests and acceptance criteria are as stated below. The work will be deemed to have failed if the test(s) does not meet the acceptance criterion.
<table>
<tr><td>Surface preparation (pH)</td><td>Refer to 6.3.10 and 10.3.4.</td></tr>
</table>
</td></tr>
</table>

Section / Reference	Proposed Change	
(CAC & GEO)		The surface preparation requirements shall be met and recorded in the quality system prior to application of coatings.
	Surface preparation (roughness)	Applicator shall document surface roughness achieved in its QA system, surface roughness shall be in accordance with manufacturer requirements, or if none provided in accordance with ICRI Guideline No 310.2, surface profile range CSP 6 to CSP 9.
	Surface preparation (moisture content)	Calcium Chloride Testing in accordance with ASTM F1869. Moisture vapour emission rate shall be within product manufacturer specified limit. Note: Infiltration shall be repaired prior to coating, as per section 6.2.5.6.
	Water : Concrete Ratio	The required water to concrete (w/c) ratio shall be followed in the application of the concrete. Bulk density measurements shall be used to verify the correct water/concrete ratio is achieved. The applicator shall include bulk density measurements as part of its quality assurance documentation prior to application. **7.19.5Bulk Density Measurement** a) Use a container of known volume and record in metres cubed) (V) (minimum 1 litre). b) Weigh empty container and record measurement in kilograms (W_0). c) Fill the container with a sample of the concrete mix, tap and scrape to level top. d) Weigh full container and record measurement in kilograms (W_1). e) Calculate bulk density using below formula: $Bulk\ Density\ (\frac{kg}{m^3}) = (W_1 - W_0)/V$ f) Check calculated density complies with table below. Bulk density measurement must be within the acceptable tolerance limit set by the manufacturer prior to application.

Section / Reference	Proposed Change	
	Thickness of coating material	Refer 10.3.11 The Applicator shall measure the thickness of applied repair and/or coating material at any location selected by the Water Agency using core samples or a non-destructive method approved by the Water Agency. Unless specified otherwise by the Water Agency, the sampling rate shall be one for every 100 m² repair area. Any area found to be <90% of specified minimum thickness shall have additional material applied, in accordance with this specification, to make up to the required thickness. Subject to the approval from the Water Agency, the sampling rate may be reduced following consistent pass results.
	Core Evaluation	Between 24 hours and 14 days following installation core samples shall be taken of the coating and host structure and tested to verify: • UCS of coating (AS 1012.9, EN 196-1, or ASTM C150/C150M) ○ See relevant water industry standard for UCS requirements (CAC – WSA 160, GEO – WSA 161) • Microscopic examination to ensure no segregation is present in the mortar. • Self-compaction: Mortar shall be self-compacting such that any voids are less than 4 mm. Verification of self-compaction: a core sample (for field application), shall be taken following initial curing. The sample shall be cut with a diamond saw to provide two cross sections. Cross sections shall be examined visually, and any voids measured. Measurement equipment: micrometer, caliper, or other suitable gauge, capable of measuring to within 0.1 mm.

Section / Reference	Proposed Change
	The testing frequency shall be as follows: • For pipeline installations: 1 sample for every 50m installed. • For maintenance hole installation: 1 sample for every 10m installed.
Table 13.4 Colour scheme for pipes, conduit and ducts in treatment facilities	Update to note 4 to Table 13.4: 4. Chemical carrying pipes shall be fully coloured/painted and labelled. Refer to the list of common pipework contents in Table 13.5.